IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPLICANT(s):	Ooi et al.		
SERIAL NO.:	09/802,084	ART UNIT:	2823
FILING DATE:	03/08/2001	EXAMINER:	Coleman, W.D.
TITLE:	QUANTUM WELL INTERMIXING		
ATTORNEY DOCKET NO.:	774-010234-US (PAR)		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450
ATTENTION: BOARD OF PATENT APPEALS AND INTERFERENCES

APPELLANTS' BRIEF

(37 C.F.R. §1.192)

This is an appeal from the final rejection of the claims in the above-identified application. A Notice of Appeal was mailed on 07/28/03. The fees required under 37 C.F.R. §1.17 are being submitted herewith. This brief is being submitted in triplicate. The appendix of claims are attached hereto.

I. REAL PARTY IN INTEREST

The real party in interest in this Appeal is:
NTU Ventures PTE LTD

II. RELATED APPEALS AND INTERFERENCES

None

III. STATUS OF CLAIMS

Claims 1-16 are pending in the application.

Claims 1-16 have been finally rejected.

The claims on appeal are 1-16.

IV. STATUS OF AMENDMENTS

A response after final rejection, which had no amendments, was considered by the Examiner and was entered.

V. SUMMARY OF INVENTION

In brief, the present invention relates to a novel and inventive method of introducing point defects in a compound semiconductor structure. The Structure is irradiated by a source of photons whose energy is at least that of the displacement energy (E_D) of one species within the compound semiconductor. Typically, the structure itself is heated to temperatures of the order of 100 °C (see Figure 5 and first paragraph, page 16) during this process.

Where energies of more than E_D are transferred by the photons, host ions in the structure are displaced. The absorption of these high energy photons therefore generates point defects in the structure.

The invention has the advantage of a highly accurate spatial control of the resulting band gap energy. In turn, this allows for the fabrication of monolithic photonic integrated circuits (PIC) and, in particular, wavelength division multiplex (WDM) sources, which have different band gap energies across a sample (see page 19, line 33, to page 20, line 1). The present invention is less expensive, has a higher throughput, and a higher yield compared to the prior art of selective area epitaxy.

The invention defined by the independent claims is:

1. A method of manufacturing a photonic integrated circuit (Fig. 12, 30) comprising a compound semiconductor structure (Fig. 7, 20) having a quantum well region, comprising the steps of irradiating the structure using a source of photons (Fig. 1, 11) to generate defects, the photons having an energy (E) at least that of the displacement energy (E_D) of at least one element of the compound semiconductor (page 7, 11. 22-25), and subsequently annealing (page 15, 11. 7-9) the structure to promote quantum well intermixing (page 15, 11. 22-24).

VI. ISSUES

1. Whether claims 1, 4, 5, 6, 7, 8 and 9 are anticipated under 35 U.S.C. 102 by Burnham.

2. Whether claims 2, 3, and 16 are obvious under 35 U.S.C. 103 over Burnham in view of Thompson.

3. Whether claims 10, 11, 12, 13, 14 and 15 are obvious under 35 U.S.C. 103 over Burnham in view of Poole and Feldman.

4. Whether claim 1 is properly provisionally rejectable on the grounds of double patenting in view of application serial No. 09/916,701.

VII. GROUPING OF CLAIMS

The claims do not stand or fall together.

The claims are grouped as follows:

Group I - claim 1;

Group II - claims 4, 5, 6, 7, 8 and 9;

Group III - claims 2, 3, and 16; and

Group IV - claims 10, 11, 12, 13, 14 and 15.

VIII. ARGUMENT

The degree of novelty and inventiveness in the present invention is amply illustrated by the fact that development of quantum well intermixing (QWI) is a highly worked field, and a survey of 81 reports published during the period 1996 to 2000 carried out by the applicants did not yield a single publication that describes or proposed a QWI process that generates defects in a compound semiconductor structure using high energy photons

and subsequent annealing, thereby facilitating the fabrication of multiple bandgap regions in a single step process.

The Examiner has rejected claims 1 and 4 to 9 on the grounds of lack of novelty. The Examiner considers that Burnham anticipates the manufacturing method of the present invention. The method in Burnham, however, is different from the present invention in a number of important respects. The method in Burnham does not introduce defects; instead the whole semiconductor structure is heated to within a few tens of °C below the thermal disordering temperature. Quantum well intermixing is induced by scanning the structure with a laser beam, those areas exposed to the laser beam being raised above the critical thermal disordering temperature. The Burnham method, therefore, is seen to require the whole structure to be raised to a high temperature, somewhere between 750 and 850°C (see column 4, line 58). No additional annealing step is required in the Burnham method because the whole structure has already been heated to this high temperature.

Claim 1 recites "…irradiating…to generate defects…" and "…annealing the structure…". Since these limitations are missing from Burnham, the rejection of claims 1 and 4-9 under 35 U.S.C. 102 should be reversed.

Further, since these limitations are not suggested by Burnham, these claims are unobvious over this reference.

As regards claim rejections on the grounds of 35 U.S.C. 103, the present invention is not only novel over Burnham, but

also represents a very significant inventive step away from the Burnham technique. It is noted that the Burnham technique provides quantum well intermixing in a way which, though it requires the full structure to be raised to a high temperature, does not require the introduction of point defects in the quantum well region. It is clear that a person having ordinary skill in the art and knowing of the teaching of Burnham would be highly unlikely to attempt to solve the problem in a new way as has been done in the present invention. The background to the Burnham case discusses only diffusion and implantation techniques on the one hand and laser beam annealing techniques on the other, the use of a source of photons to generate defects where the photons have an energy which is at least the displacement energy (E_D) is neither taught nor suggested.

The applicants contend that the combination of the teachings of Burnham and Thompson fails to teach a method according to claim 2. It is clear from a full reading of Thompson that the plasma (ECR) source is not a radiation source for the purposes of the Thompson document. It is rather a source of helium particles which provides the required helium particle flux for in situ epigrowth interference. Furthermore, it is unclear why a person of ordinary skill would wish to dispense with the laser annealing process of the Burnham technique and incorporate a defect layer growth technique in its place. However, when the Burnham and Thompson teachings are combined, the resulting hybrid would still not disclose a step of irradiating a compound semiconductor structure with a source of photons to generate defects, as claimed in claims 1 or 2 of the present application.

The ECR plasma source taught in Thompson is not a radiation source in the sense of present claims 1 or 2 (i.e. it is not a source of photons having an energy at least that of the displacement energy). The Examiner's objections at items 13 and 15 are therefore traversed.

Thus the rejection of claims 2, 3 and 16 under 35 U.S.C. 103 on this combination of references should be reversed.

The Examiner also rejects claims 10 through 15 on the grounds of lack of inventive step in view of a combination of the teaching of Burnham with that of Poole et al. and Feldman et al. The Poole disclosure relates to an ion implantation technique for introducing point defects. To achieve disordering in localized regions, Poole discloses a patterned silica mask. The silica mask is not a gray tone mask or for that matter a photo resist as claimed in claim 10. The mask used in Poole is of a single predetermined thickness. Silica can only pass through where the mask has holes. It therefore requires repeated application of the shadow mask to build up a grayscaled pattern on the wafer [see step 3 in Fig. 8b of Poole]. As explained above it appears highly unlikely that a person of ordinary skill in the art would take the teaching of Burnham, combine it with the quite different ion implantation technique of Poole, and, without the exercise of inventiveness, arrive at a third technique: radiation-induced generation of defects within the quantum well region. As was emphasized above, it should also be noted that the dielectric-based selective ion-implantation induced disordering method described by Poole is only one of the many possible (different) ways to achieve

selective quantum well intermixing that is currently being investigated.

Feldman discloses the method of using gray scale mask to manufacture optical elements. Given the unlikelihood of a combination of the teaching of Burnham and the teaching of Poole, the obviousness of a further incorporation of the teachings of Feldman from a third field of technology is vanishingly small. The whole teaching of Feldman is the fabrication of three-dimensional graded profiles on a photo resist, which is then subsequently transferred by etching onto the substrate to form the end result, a micro-optical element. Nowhere in Feldman is there any teaching of the use of these patterned micro-optical elements as masks for controlling the degree of quantum well intermixing. This is not surprising given the distinct nature of the fields to which the Burnham, Poole and Feldman applications respectively relate.

Thus, the rejection of claims 10-15 under 35 U.S.C. 103 on this combination of references should be reversed.

On double patenting, the Examiner has correctly identified that the current application and the reference cited in the Examiner's report share a common inventor, namely OOI Boon Siew although the inventive entity is different. However it is noted that the method of quantum well intermixing claimed in US 2002/0072142 A1 is a variant on the ion implantation method, the variant being referred to as Thermally Assisted Implantation Vacancy Induced Diordering (TAIVID). There is no conflict between the claims of the present invention and those of the referenced document, since TAIVID explicitly requires the

introduction of ions into a quantum well structure in order to induce defect formation. Additionally, the TAIVID method contrasts with the method claimed in the present application in that the TAIVID method does not teach or suggest using high energy photons to induce such point defects.

The TAIVID method introduces ions into the quantum well structure at an elevated temperature (said to be in the range from 200°C to a temperature near the characteristic crystal damage temperature for the quantum well crystal structure). This elevated temperature ion implantation is followed by a later annealing step, whereby quantum well intermixing is induced.

Since the present claim 1 defines a patentably distinct invention from that of claims 5, 33, 38, 39 and 41 of said application, the attempted double patenting rejection should be reversed.

In conclusion this Honorable Board is requested to reverse the rejection of claims 1-16.

The appendix of claims is attached hereto. A check in the amount of $320 is enclosed herewith for the appeal brief fee. The Commissioner is hereby authorized to charge payment for any additional fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

Henry I. Steckler

Henry I. Steckler
Reg. No.: 24,139

Sept 22, 2003
Date

Perman & Green, LLP
425 Post Road
Fairfield, CT 06824
(203) 259-1800
Customer No.: 2512

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date indicated below as first class mail in an envelope addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, Attention: BOARD OF PATENT APPEALS AND INTERFERENCES

Date: 9/22/03

Signature: Carolina Rodriguez
Person Making Deposit

IX. APPENDIX OF CLAIMS

The texts of the claims involved in the appeal are:

1. A method of manufacturing a photonic integrated circuit comprising a compound semiconductor structure having a quantum well region, comprising the steps of irradiating the structure using a source of photons to generate defects, the photons having an energy (E) at least that of the displacement energy (E_D) of at least one element of the compound semiconductor, and subsequently annealing the structure to promote quantum well intermixing.

2. A method according to claim 1, in which the radiation source is a plasma.

3. A method according to claim 2, in which the plasma source is generated using an electron cyclotron resonance (ECR) system, an inductively coupled plasma (ICP) system, a plasma disk excited by a soft vacuum electron beam, or plasma soft x-ray (SFR) devices.

4. A method according to claim 1, in which the radiation source is one selected from a group consisting of electrical gas discharge devices, excimer lasers, synchrotron devices, flash x-ray devices and gamma ray sources.

5. A method according to claim 1, including the step of masking a portion of the structure to control the degree of radiation damage.

6. A method according to claim 5, in which the mask is adapted to prevent intermixing entirely.

7. A method according to claim 5, in which the structure is masked in a differential manner to selectively intermix the structure in a spatially controlled manner by controlling the exposure of portions of the structure in a predetermined manner.

8. A method according to claim 5, in which the mask is selected from a group consisting of binary masks, phase masks, gray masks, dielectric or metal masks, and photoresist masks.

9. A method according to claim 1, in which spatial control of intermixing is controlled using a variable profile mask pattern.

10. A method according to claim 1 further comprising the steps of forming a photoresist on the structure and differentially exposing regions of the photoresist in a spatially selective manner in dependence on the degree of quantum well intermixing required, and subsequently developing the photoresist.

11. A method according to claim 10, comprising the step of applying an optical mask to the photoresist and exposing the photoresist through the optical mask, the optical mask having an optical transmittance that varies in a spatially selective manner.

12. A method according to claims 11, in which the optical mask is a Gray scale mask.

13. A method according to claim 10, in which the photoresist is applied to a masking layer.

14. A method according to claim 13, in which the masking layer is a dielectric.

15. A method according to claim 13, further comprising the step of etching the structure with the developed photoresist in situ to provide a differentially etched masking layer.

16. A method according to claim 1, in which an electron cyclotron resonance system is used to generate a plasma, wherein the microwave power of the ECR system is between 300 and 3000 W, more preferably between 1000 and 2000 W, the process temperature is between 25 and 500°C, more preferably between 25 and 200°C, the process pressure is between 0.1 and 100 mTorr, more preferably between 20 and 50 mTorr, and the exposure time is between 30 seconds and 1 hour, more preferably between 4 and 14 minutes.